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EVALUATION OF THE PROPOSED LAMBERT-ST. LOUIS INTERNATIONAL AIRPORT EXPANSION

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16. Abstract

This report summarises the effects of the STL Master Plan Supplement on the performance of the National Airspace system (NAS). The National Airspace System Performance Analysis Capability (NASPAC) Simulation Modeling System was used to perform this task. This study used the model to calculate local and system-wide delays, with and without the new runway, as identified in the STL Master Plan Supplement. Monetary benefits of the Master Plan was derived using the NASPAC Cost of Delay Module. The Cost of Delay Module calculates the passenger and operational delay cost based on actual cost reported by the airlines to the Department of Transportation's Office of Avation Statistics. The results indicate that The STL Master Plan Supplement will provide monetary benefits to the airlines and user community. This is because operational and passenger delays are abated locally (STL) and NAS. This is due to the increase in airport capacity at STL.

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The authors also acknowledge the support of : Tom Coates, ACE-611E, Roy O'Conner of the STL TRACON for his assistance in deriving the STL airport and the sector capacity values used with the improvement cases, and Bruce Hoover and Jim Hamilton of ZKC for providing the ACES data that produced the current sector design. We also acknowledge Leigh Fisher Associates who prepared the Master Plan Supplement Study Lambert-St. Louis International Airport for the City of St. Louis Airport Authority. Without the support and help of all these people, this study would have not been possible.

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EXECUTIVE SUMMARY

The St. Louis Master Plan shows that traffic at St. Louis will increase 35 percent by the year 2010. This level of traffic is expected to have detrimental effects on St. Louis, the surrounding metropolitan area and the National Airspace System. To more fully understand and evaluate possible alternative solutions to mitigate the congestion problems anticipated, the FAA decided to conduct a systematic study of alternative airport strategies.

The City of St. Louis, Missouri Airport Authority and the Federal Aviation Administration (FAA) are working together to increase the capacity at Lambert-St. Louis (STL) International Airport. The enhancements at STL are designed to meet the increase in traffic expected into the 21st century.

The airport improvements include the construction of a new 9,000-foot parallel northwest-southeast runway, located approximately 2,800 feet southwest of existing Runway 12R/30L. After the construction of the new parallel runway, the existing Runway 12R/30L would be redesignated as Runway 12C/30C, and the new runway would be designated as Runway 12R/30L, which is located to the west of Runway 6/24. The new parallel runway would require construction of a runway/taxiway bridge across Lindbergh Boulevard. It is also proposed that a 2,500 foot extension to Runway 12C/30C be added in the future to accommodate heavy jets. The extension would also require a runway/taxiway bridge across Lindbergh Boulevard. Figure E-1 shows the current STL airport layout. Figure E-2 represents a guide for Airport capacity enhancement to satisfiy the needs projected through the year 2015.

This study was conducted at the William J. Hughes FAA Technical Center by the Aviation System Analysis and Modeling Branch, ACT-520, under the sponsorship of the Investment Analysis and Operations Research Branch, ASD-430. The analysis was performed at the request of the FAA Central Region, Airports Division, ACE-611E.

The study team used the National Airspace System Performance Analysis Capability (NASPAC) Simulation Modeling System to simulate the essential elements of the Master Plan and to estimate their impact on National Airspace System (NAS) performance. NASPAC simulations were used to calculate local (STL) and system-wide delays, with and without the Master Plan.

The baseline cases for future years were developed from the Aviation System Capacity Plan and the Terminal Area Forecast (TAF) for STL. These forecasts were modified to reflect expected conditions without the STL Master Plan. This was done to eliminate the increase in future traffic that is already expected by the Terminal Area Forecasts (TAF), since it presumes the construction of the added runway.

The delay savings represent the difference in delay, with and without the recommended Master Plan improvements. These savings, presented in 1996 dollars, were developed using the NASPAC Cost of Delay Module and direct airline operating expenses for 1996.

The delay savings assume that the current National airspace System stays essentially the same for the study period, with some new technologies introduced, and some airspace procedures revised.

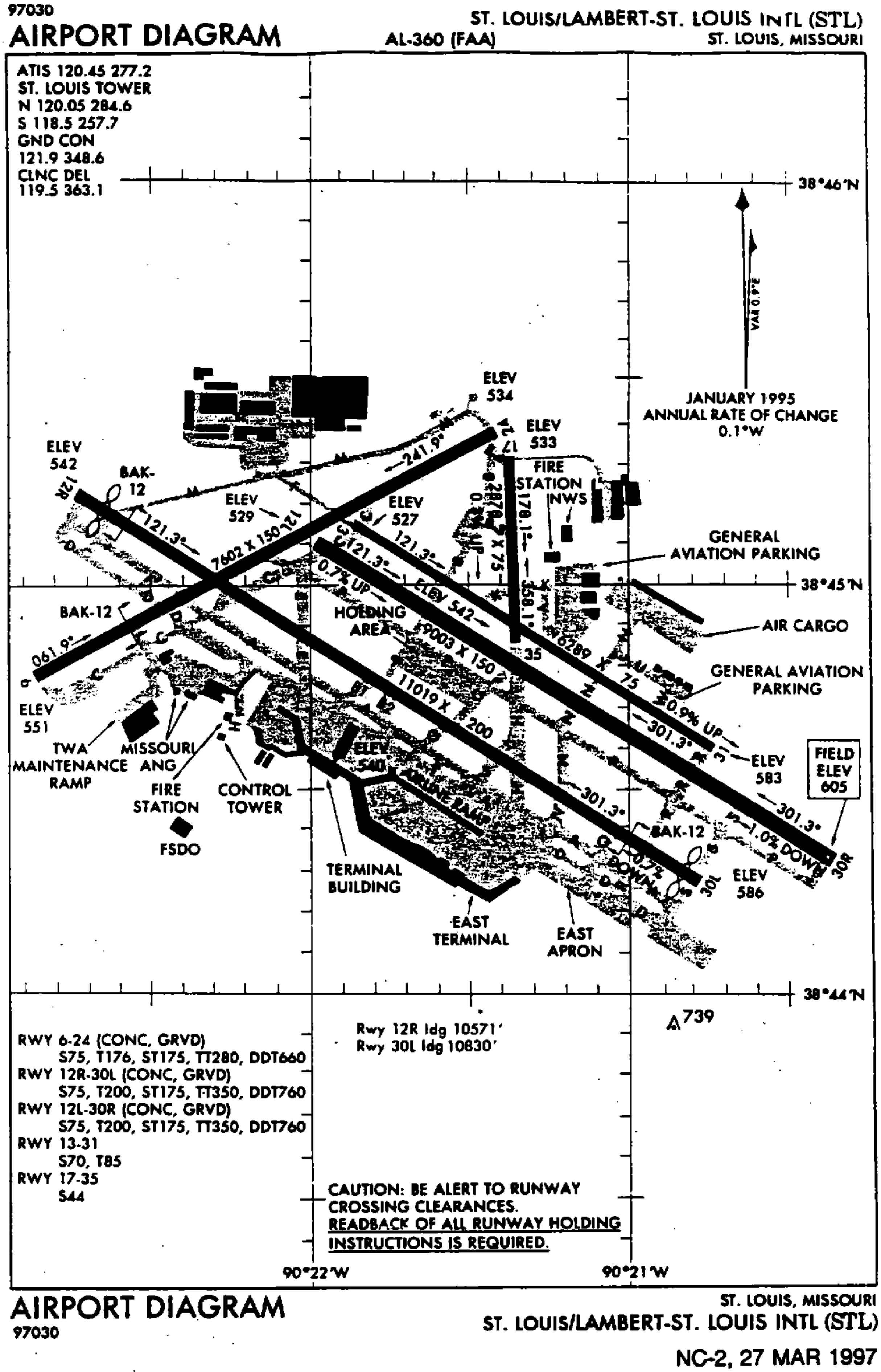
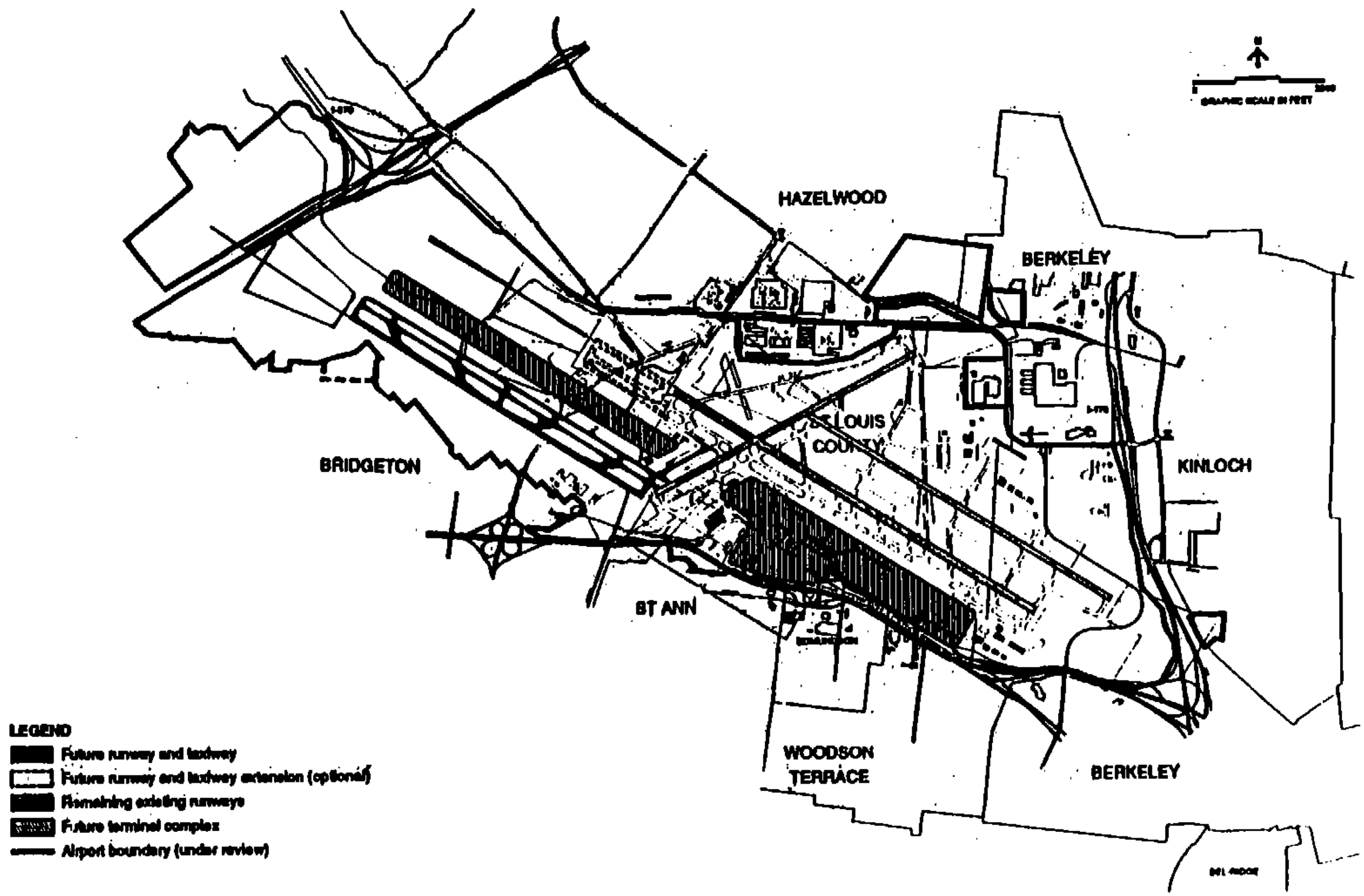


FIGURE E-1. ST. LOUIS/LAMBERT - ST. LOUIS INTL (STL)

RECOMMENDED MASTER AND LAND USE PLAN FOR ST. LOUIS INTERNATIONAL AIRPORT



New Facilities

- One parallel runway at least 2,800 feet to the south of existing Runway 12R-30L and west of existing Runway 6-24.
- Extension of existing Runway 12R-30L approximately 2,500 feet to the west (optional).
- Two runway/taxiway bridges across Lindbergh Boulevard.
- Ultimately, an expanded terminal complex.

FIGURE E-2. STL PROPOSED IMPROVEMENTS

It was beyond the scope of this study to estimate the relative merits of alternate procedural or technological opportunities to address the congestion problem at St. Louis airport.

RESULTS

The STL Master Plan is expected to provide monetary benefits based on the reduction in operational and passenger delay both locally (STL) and system-wide, due to the increase in airport capacity. Table E-1 shows the yearly operational and passenger delay savings for the years 2005-2015 at STL. The future years 2005, 2010, and 2015 were modeled, and linear interpolation was used to estimate the savings for the years that were not modeled. Operational delay occurs whenever an aircraft has to compete to use an ATC system resource. On the other hand, passenger delay reflects the ripple-effects in the system and shows the lateness of a flight at the destination airport.

TABLE E-1. STL AIRPORT YEARLY DELAY AND SAVINGS WITH THE STL MASTER PLAN (Savings in 1996 Dollars)

Years	Operational Delay		Passenger Delay	
	Hours	Savings	Hours	Savings
2005	80,486	$141,354,000	51,778	$103,943,000
2006	83,634	146,063,000	53,129	105,834,600
2007	86,782	150,772,000	54,480	107,726,200
2008	89,930	155,481,000	55,831	109,617,800
2009	93,078	160,190,000	57,182	111,509,400
2010	96,227	164,900,000	58,534	113,401,000
2011	100,216	176,838,000	63,516	128,546,000
2012	104,205	188,776,000	68,498	143,691,000
2013	108,194	200,714,000	73,480	158,836,000
2014	112,183	212,652,000	78,462	173,981,000
2015	116,170	224,590,000	83,445	189,126,000
Totals	**1,071,105**	**$1,922,330,000**	**698,335**	**$1,446,212,000**

Table E-2 shows the system-wide yearly savings in operational and passenger delay cost for the eleven year period (2005-2015).

TABLE E-2. SYSTEM-WIDE YEARLY DELAY AND COST SAVINGS WITH THE STL MASTER PLAN (Savings in 1996 Dollars)

Years	Operational Delay		Passenger Delay	
	Hours	Savings	Hours	Savings
2005	96,247	$169,543,000	163,123	$340,679,000
2006	123,649	210,673,400	192,534	376,697,600
2007	151,051	251,803,800	221,945	412,716,200
2008	178,453	292,934,200	251,356	448,734,800
2009	205,855	334,064,600	280,767	484,753,400
2010	233,259	375,195,000	310,176	520,772,000
2011	285,086	482,437,400	416,380	806,630,600
2012	336,913	589,679,800	522,584	1,092,489,200
2013	388,740	696,922,200	628,788	1,378,347,800
2014	440,567	804,164,600	734,992	1,664,206,400
2015	492,395	911,407,000	841,197	1,950,065,000
Totals	**2,672,180**	**$5,118,825,000**	**4,563,842**	**$9,476,092,000**

CONCLUSIONS

Table E-3 shows the cumulative savings for the 11-year period 2005-2015 at STL and system-wide. The cumulative operational delay savings would be $1.9 billion at STL and $5.1 billion system-wide. The cumulative passenger delay savings would be $1.4 billion at STL and $9.5 billion system-wide.

The results clearly indicate that the STL Master Plan improvements will reduce delay at STL and system-wide and indicate monetary savings to the travelers of the city of STL and the NAS as a whole. These savings are based on the value of travel time of $45.50 per hour for each traveler and approximately $1800 for airline operation. These are not cash savings, but simply the value of time saved.

TABLE E-3. CUMULATIVE SAVINGS WITH THE MASTER PLAN FOR 11-YEAR PERIOD 2005-2015

(Savings in 1996 Dollars)

Total	Operational Delay Savings	Passenger Delay Savings
STL Airport	$1.9 billion	$1.4 billion
System-wide	$5.1 billion	$9.5 billion

Even though it seems natural to combine the operational and the passenger delay to obtain the grand total delay, it is not recommended because of the way NASPAC calculates these two metrics. Passenger delay reflects the ripple-effects in the system and shows the lateness of a flight at the destination airport. On the other hand, operational delay occurs whenever an aircraft has to compete to use an ATC system resource. Whenever operational delay is taking place, passenger delay is accumulating at the same time because the operational delay contributes to passenger delay. If these two delay metrics are combined, the results will be overestimated.

However, since the cost of delay to the passengers and carriers consists of different components, and the passengers value of time is independent of direct airline operating expenses, the operational delay cost and the passenger delay cost may be added to show the full benefits of the STL Master Plan improvements. Operational costs include crew salaries, maintenance, fuel, equipment, depreciation, and amortization, they are reported by the airlines on a quarterly basis. Passenger costs are derived from the expected number of passengers on a flight multiplied by the FAA-endorsed value of $45.50 per hour of delay, multiplied by delay hours.

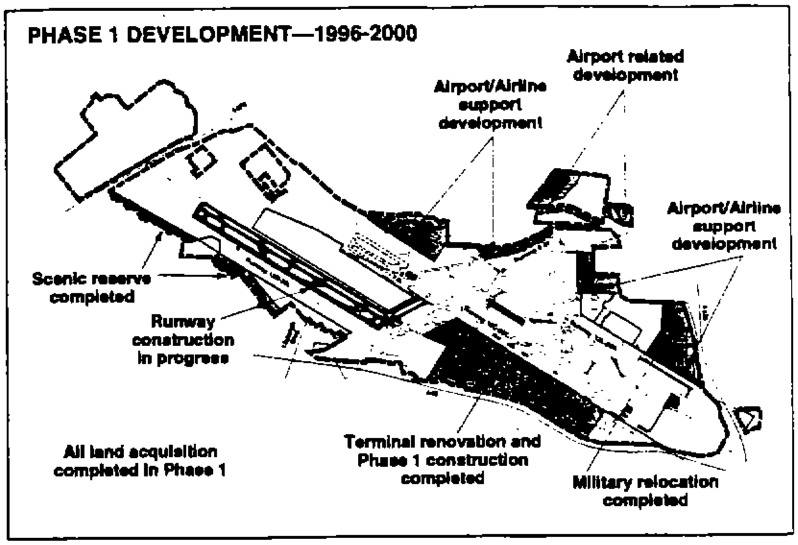
1. INTRODUCTION

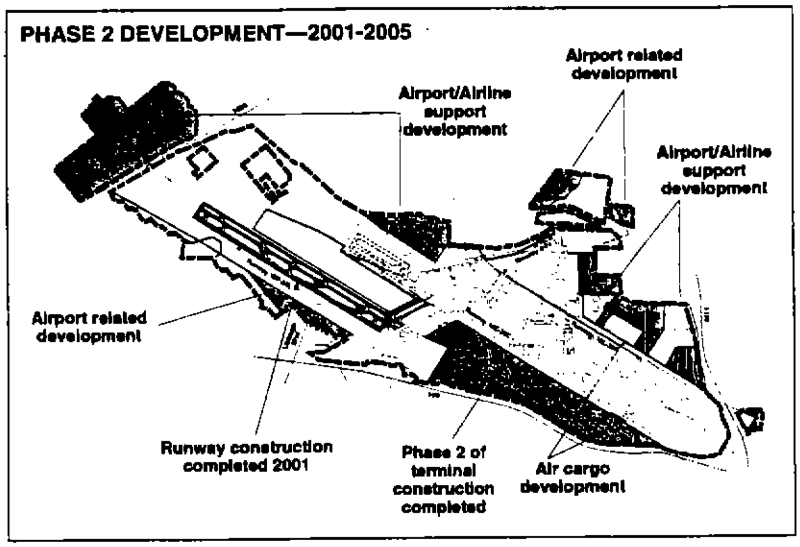
The City of St. Louis, Missouri Airport Authority and the Federal Aviation Administration (FAA) are working together to increase the capacity at Lambert-St. Louis (STL) International Airport. The enhancements at STL are designed to meet the expected increase in growth of air travel into the 21st century.

These enhancements include the construction of a new 9,000-foot parallel northwest-southeast runway, located approximately 2,800 feet southwest of existing Runway 12R/30L. After the construction of the new parallel runway, the existing Runway 12R/30L would be redesignated as Runway 12C/30C, and the new runway would be designated as Runway 12R/30L, which is located to the west of Runway 6/24. The new parallel runway would require construction of a runway/taxiway bridge across Lindbergh Boulevard. In addition, it is proposed that a 2,500 foot extension to Runway 12C/30C be added in the future to accommodate heavy jets. The extension would also require a runway/taxiway bridge across Lindbergh Boulevard. The preliminary phasing for the proposed improvements in the next 20 years is shown in Figure 1 (presented in Master Plan Supplement Study as Exibit I). The timing of major construction elements of the proposed new runway development and related developments through 2005 is presented in Table 1.

Additional enhancements of taxiways to the terminal area are designed to relieve existing and potential congestion problems, and to maximize the operational efficiency and safety of the airport (Leigh Fisher Associates, January 1996). These enhancements include:

1. Two new northwest-southeast taxiways, parallel to and north of the new Runway 12R/30L.
2. Two additional taxiways, parallel to and northwest of Runway 6/24, connecting the existing airfield to the new runway and taxiway complex.
3. Additional high-speed exit taxiways serving Runway 12L/30R.
4. Bypass taxiway east of Runway 12C/30C, connecting Taxiway D with the eastern threshold of Runway 12L/30R.
5. Aircraft hold pads at the east end of Runway 12L/30R and both ends of Runway 12C/30C.
6. Filling in taxiway "island" bounded by the terminal apron and Taxiways A, E, and H.
7. Additional aircraft holding area, adjacent to Taxiway P, located between Taxiways B and E.
8. New taxiway connecting Taxiways D and P, located between Taxiways N and Q.
9. New taxiway parallel to Taxiway C, located between Taxiway P and Runway 12L/30R.





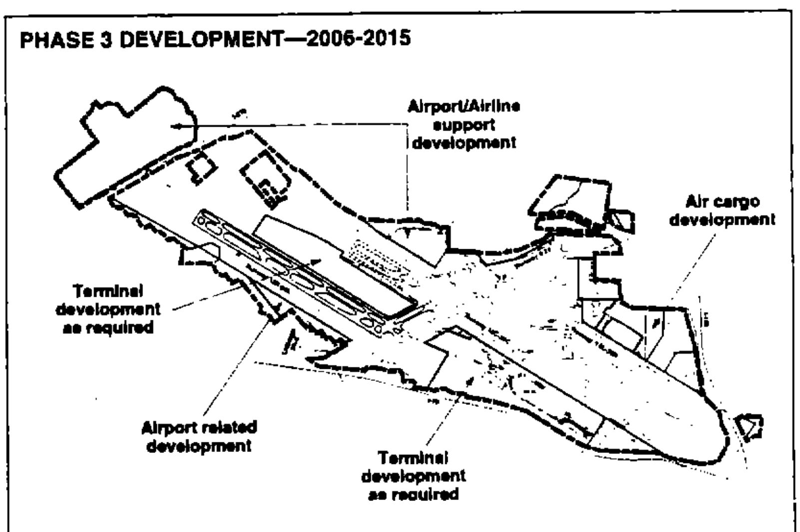


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Exhibit I

PHASING PLAN

Master Plan Supplement Study
Lambert-St. Louis International Airport

January 1996

FIGURE 1. STL MASTER PLAN PHASING PLAN

LFA LEIGH FISHER ASSOCIATES

MAJOR CONSTRUCTION ELEMENT	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Land acquisition and related projects										
Commercial and residential land acquisition	■	■	■							
Tenant relocation		■	■	■						
Airfield construction projects										
New runway and taxiways			■	■	■					
Airside service roadways					■					
Aircraft fuel and glycol systems				■	■	■				
Airline support facilities	■	■	■	■	■					
Aircraft rescue and fire fighting facilities	■									
Airfield lighting, signage, and navaids				■	■					
General improvements	■	■	■	■	■	■	■	■	■	■
Terminal construction projects										
Renovation of existing terminal	■	■							■	
New terminal facilities		■	■				■	■		
People-mover system							■	■		
Cargo facilities project							■	■		

STL059663

Source: Leigh Fisher Associates, January 1996

Exhibit J

PRELIMINARY SCHEDULE FOR DEVELOPMENT

Master Plan Supplement Study
Lambert-St. Louis International Airport
January 1996

LEIGH FISHER ASSOCIATES

TABLE 1. STL MASTER PLAN PRELIMINARY SCHEDULE FOR DEVELOPMENT

10. Conversion of Runway 13/31 to Taxiway F and extension of Taxiway F to the east threshold of Runway 12L/30R.

To simulate the impacts of these improvements, the NASPAC *Simulation Modeling System* (SMS) was used to measure throughput and delay at STL and throughout the National Airspace System (NAS). NASPAC is a tool used by the FAA to evaluate the performance of the NAS. It is also used for strategic planning, identifying bottlenecks in the system, and evaluating alternative solutions to capacity and demand related issues.

The cost of delay module (Baart, Richie, & May 1991) was used to estimated delay costs. System-wide delay and cost of delay were recorded by location. The following list describes where flights may accumulate delay:

a. departure fix crossing.

b. arrival fix crossing.

c. miles-in-trail restriction.

d. sector entry crossing.

e. airport arrival.

f. airport departure.

g. at-gate arrival (passenger delay).

1.1 BACKGROUND

In 1988, the City of St. Louis Airport Authority initiated a major study to determine future development of STL International Airport. This study was completed in 1992 and was known as the 1992 Master Plan Forecast. Chapter 2 of this report concluded that several significant events since 1987 have contributed to the growth of air traffic at STL and that the airport needed to expand to meet the expected increase in future growth. Since then, the City of St. Louis Airport Authority and the FAA have concluded that the nature of these events required a supplement study to the 1992 Master Plan.

The Master Plan Supplement Study, provides the basis for evaluating recommendations in the 1992 Master Plan, and will be used to guide the development of STL beyond the year 2015. This report provides a summary of the results of the technical, environmental, economic, and financial studies, resulting in an update of the Lambert-St. Louis International Airport Master Plan. These two reports are well documented and will answer any question concerning the improvements at STL. Throughout this report the terms "STL Master Plan Supplement" and "STL Master Plan" are used interchangeably in the analysis.

A review of the historical national and international events by the City of St. Louis Airport Authority, lead to the update of the 1992 Master Plan Forecasts. Between 1987 and the 1996, traffic demand at STL was believed to have been affected by the following events (Leigh Fisher Associates, January, 1996):

1. A reduction in connecting service in the late 1980s, resulting from consolidation of service of TWA and Ozark Airlines subsequent to their merger in 1986.

2. A national economic recession in 1990 and early 1991 that affected airline traffic nationally and at STL.

3. The Persian Gulf War in early 1991 that depressed international travel worldwide and to some extent domestic travel in the United States.

4. Financial uncertainties experienced by TWA and its filing for reorganization under Chapter 11 of the U.S. Bankruptcy code, and its subsequent emergence from bankruptcy in late 1993. TWA filed again under Chapter 11 on June 30, 1995, and emerged from bankruptcy on August 25, 1995, with a revised financial plan.

5. A major fare war by the nation's airlines in the summer of 1992 that stimulated an increase in passenger traffic during the period when fares were reduced.

6. A major expansion at STL by Southwest Airlines (hub) started in 1991.

7. The continuing growth in the national economy and related reductions in unemployment since 1992.

8. Transfer of some of TWA's St. Louis service to Atlanta to begin operating a hub, subsequent decision in 1994 to return this service to St. Louis, and consequent resurgence of TWA passenger volume.

The experts believe some of these events will have long-term effects on the traffic growth at STL, rather than short term.

1.2 STUDY PURPOSE AND OBJECTIVES

This study analyzed the current operations and the proposed changes to STL, as outlined in the Master Plan Supplement Study, Lambert-St. Louis International Airport (Leigh Fisher Associates, January 1996), and provides delay and cost measures for STL and the NAS.

To accomplish this task, operations were simulated based on future traffic as projected by the Terminal Area Forecasts (TAF), FAA-APO-95-12, (FY 1995 - 2012), for STL. The complete set of data include:

1. current and future capacity estimates.

2. new sector designs for the low, high, and super-high altitudes.

3. new arrival and departure fixes.

4. 2005, 2010, and 2015 traffic profile.

The study was conducted at the request of the FAA Central Region, Airports Division, ACE-611E, and approved by the Operations Research and Analysis Branch, ASD-430. The FAA William J. Hughes Technical Center's Aviation System Analysis and Modeling Branch, ACT-520, simulated the changes using the NASPAC SMS. The final results were analyzed and presented in this report.

2. TECHNICAL APPROACH

This section provides a brief overview of the NASPAC modeling system, describes the system metrics, and defines the scenarios used in this study.

2.1 WEATHER ANNUALIZATION

The MITRE Corporation developed a method for computing annual results of NASPAC-based analysis. Six scenario days are selected as representative of varying levels of instrument meteorological conditions (IMC) and visual meteorological conditions (VMC) across the 58 NASPAC airports. To compute the annual results, weighting factors for each scenario day are applied according to the frequency of occurrence of similar days that were observed in year 1990. Table 2 shows the weights applied to the six scenario days.

As a means of determining where the majority of the delay was occurring, ground and airborne delays were summarized and presented on a system level and for individual airports. Ground delay consists of pushback delay at a gate, taxi delay to and from active runways including the departure queue delay, and arrival delay caused by occupied runways. Airborne delay is caused by airspace capacity limitations. Airborne delay accumulates when flights have to compete for ATC resources, such as flow control restrictions, arrival and departure fixes, sectors, and runways.

TABLE 2. WEIGHTING FACTORS FOR THE SIX WEATHER SCENARIO DAYS

Percent (%) VMC	Scenario Day Chosen	Weighting Factor
95% - 100%	January 13, 1990	80.00
90% - 95%	September 27, 1990	127.50
85% - 90%	May 16, 1990	86.25
80% - 85%	March 10, 1990	23.75
70% - 80%	March 31, 1990	17.50
< 70%	December 22, 1990	30.00

2.2 SCENARIO DEFINITIONS

The six scenario days used were defined by several variables such as weather, airspace geometry, routes, new procedures, time frame, and demand. The first day was based on weather observed on January 13, 1990, when most of the country was under Visual Meteorological Conditions (VMC) for 95-100 percent of the day. Under these conditions, all airports in the NAS, including STL, were at or near their maximum capacities. The second day's weather was similar to March 10, 1990, when most of the system was under VMC for 80-85 percent of the day; and the actual capacity of some airports was reduced by 15 percent due to weather conditions. The third day was the second most severe of the six days selected; the weather reflected March 31, 1990, when most of the system was under VMC for 70-80 percent of the day and the actual capacity off some airports was reduced by 20 percent due to weather conditions. The fourth day's weather is similar to May 16, 1990, when most of the system was under VMC for 85-90 percent of the day and the actual capacity of some airports was reduced by 10 percent due to weather conditions. The fifth day had weather comparable to September 27, 1990, when most of the system was under VMC for 90-95 percent of the day and the actual capacity of some airports was reduced by 5 percent due to weather conditions. The sixth day was the most severe day selected, with weather similar to December 22, 1990; most of the system was under VMC less than 70 percent of the day and the actual capacity of some airports was reduced by at least 30 percent due to weather conditions. The weights provided in Table 2 (see p.17) were used to annualize the results, such as delay and cost estimates.

The capacity estimates at STL and the other modeled airports were influenced by weather conditions. This is due to the limitation of the runway configurations enforced during periods of poor weather conditions. VMC provides the maximum capacity, mainly because of the use of visual approach procedures. The capacity decreases under IMC because arriving aircraft must use instrument approaches procedures which require increased in-trail separation. This depends on severity of weather conditions, FAA regulations, and the inability of the arriving traffic to perform simultaneous approaches at some airports.

The definitions of the scenarios also include the selection of a time frame and the improvements studied. The following seven cases were analyzed:

1. 1995 with present STL demand and present capacity (baseline).

2. 2005 with future demand and present capacity (no improvements) at STL.

3. 2005 with future demand and all improvements stated in the STL Master Plan Supplement Study in place.

4. 2010 with future demand and present capacity (no improvements) at STL.

5. 2010 with future demand and all improvements stated in the STL Master Plan Supplement Study in place.

6. 2015 with future demand and present capacity (no improvements) at STL.

7. 2015 with future demand and all improvements stated in the STL Master Plan Supplement Study in place.

Table 3 shows the scenario design of the study in a 6 x 7 matrix. The far left column represents the scenario days modeled. The column headings indicate the years modeled, including 1995 baseline, as well as the future years with and without the improvements.

TABLE 3. SCENARIO STRUCTURE

SCENARIO DAY	1995 BL	2005 BL	2005 IM	2010 BL	2010 IM	2015 BL	2015 IM
JAN 13	X	X	X	X	X	X	X
SEP 27	X	X	X	X	X	X	X
MAY 16	X	X	X	X	X	X	X
MAR 10	X	X	X	X	X	X	X
MAR 31	X	X	X	X	X	X	X
DEC 22	X	X	X	X	X	X	X

BL - baseline IM - improvement

The X's represent the scenarios actually run, including capacity, future demand, Estimated Departure Clearance Times (EDCT's) ground delay programs, and airspace route structure. These improvements were modeled by changing the airport capacity at STL, revising the arrival and departure fix attributes, and the sector load.

Airport capacity estimates used in the scenarios were based on airfield improvements that were outlined in the Aviation System Capacity Plan for the year 2005, and the STL Master Plan Supplement. In addition, advances in technology expected to be completed by the year 2005 were also included. These technological improvements, designed to increase airport capacity, are summarized in Section 4 of this report. Of the proposed expenditures contained in the Aviation System Capacity Plan, 24 airports modeled by NASPAC were identified to receive funding for either new runways or runway extensions. Funding for these airport improvements is derived from local, state, and federal agencies. Table 4 lists all of the airport improvements that were included in the simulation and are assumed to be in place for the future years.

Table 4. AIRPORT IMPROVEMENTS MODELED

Identification	Type of Improvement	Specifics
ATL	New commuter runway	3,000 ft south (5th parallel).
BWI	New parallel runway	10R/28L.
CLT	New parallel runway	18W/36W, assume Instrument Flight Rule (IFR).
DEN	New Denver Airport	(DIA).
DFW	Two new runways	16/34 and 18/36.
DTW	Two new runways	9R/27L and 4/22.
FLL	Runway extension	9R/27L.
IAD	New runway	1W/19W.
IAH	Two new runways	8L/26R and 9L/27R.
IND	New runway	5R/23L.
MCO	New runway	17L/35R.
MEM	New runway	18L/36R.
MKE	New runway and extension	7L/25R and 1L/19R.
MSP	New runway	11/29W.
MSY	New runway	1L/19R.
PHL	New runway	8/26.
PHX	New runway	8S/26S (3rd parallel).
PIT	New runway	10S/28S.
SDF	Two new runways	17L/35R and 17R/35L (parallels).
SEA	New runway	16W/34W.
SLC	New runway	16W/34W.
STL	New runway	12L/30R, 4,300 ft from parallel.
SYR	New parallel runway	10L/28R.
TPA	New parallel runway	18/36.

3. NASPAC OVERVIEW

The NASPAC SMS is a discrete event simulation model that tracks aircraft as they progress through the NAS and compete for ATC resources. Resources in the model include airports, sectors, flow control restrictions, and arrival and departure fixes. NASPAC evaluates system performance based on the demand placed on resources modeled in the NAS and records statistics at the 50 busiest national airports and 8 associated airports. See Appendix A for a complete list of airports and identifiers. NASPAC simulates system-wide performance and provides a quantitative basis for decision making related to system improvements and management. The model supports strategic planning by identifying air traffic flow congestion problems and examining solutions.

NASPAC analyzes the interactions between many components of the airspace system and the system reaction to projected demand and capacity changes. Because the model was designed to study nation-wide system performance rather than localized airport changes in detail; airports are modeled at an aggregate level. The model shows how improvements to a single airport can produce effects on delay that ripple through the NAS. Each aircraft itinerary consists of many flight legs that an aircraft will traverse during the course of a day. If an aircraft is late on any of its flight legs, successive flight legs may be affected. This is the way passenger delay accumulates.

NASPAC records two different types of delay, passenger and operational. Passenger delay is the difference between the scheduled arrival time contained in the Official Airline Guide (OAG) and the actual arrival time as simulated by NASPAC. Operational delay is the amount of time that an aircraft spends waiting to use an ATC system resource. When an aircraft arrives early, the delay is zero.

Traffic profiles consist of scheduled and unscheduled demand for each modeled airport. Scheduled demand is derived from the OAG and is used as the baseline from which future growth is projected. Unscheduled demand is determined from daily and hourly distributions taken from tower counts. Projected traffic growth is provided by the TAF.

Key output metrics are recorded in the model include delay and throughput at airports, departure fixes, arrival fixes, restrictions, and sectors, system wide and at all modeled airports. Operational delay consists of airborne and ground delay. Airborne operational delay is the delay that a flight experiences from takeoff through navigational aids, sectors, and static and dynamic flow control restrictions. Ground operational delay or airport induced delay accumulates when an aircraft is ready to depart, but has to wait for a runway to taxi-out or take off from, or when airfield capacity limitations prohibit the aircraft from landing. Operational delay contributes to passenger delay and is assigned to the flight's destination airport. Sector entry delay occurs when the instantaneous aircraft count or hourly aircraft count parameters for that sector are exceeded. Monetary assessments are derived by translating delay into measures of cost to the user by using the Cost of Delay Module. The Cost of Delay Module was incorporated into version 3.1 of the NASPAC SMS.

3.1 COST OF DELAY MODULE

The Cost of Delay Module was used to translate delay into costs to the airlines and the user community. The Origin and Destination Survey, Form 41, for the last quarter of 1996, acquired from the Office of Airline Statistics (K-25), was used to calculate operational and passenger delay cost estimates. Operational costs include crew salaries, maintenance, fuel, equipment, depreciation, and amortization, they are reported by the airlines on a quarterly basis. The data are categorized into airborne and ground delay costs by carrier and aircraft type. Passenger costs are derived from the expected number of passengers on a flight multiplied by the FAA-endorsed value of $45.50 per hour of delay, multiplied by delay hours. Form 41 was used to estimate aircraft occupancy values.

4. ASSUMPTIONS AND CAVEATS

This study assumes that the Master Plan Supplement Study is in place. The standard VFR at STL has a ceiling of 5,000 feet at mean sea level (MSL) and visibility of 3 miles. Under IFR, the ceiling and visibility is less than VFR.

The ceiling and visibility at any airport determines the capacity for that airport. For example, in a previous NASPAC study at DFW under VMC, the maximum capacity (arrival/departure) is 296 aircraft per hour with all 5 runways operational. This is based on the acceptance rate of 160 aircraft, that is, the number of arriving aircraft in 1 hour. Under IFR, the maximum capacity is 180 aircraft, based on an acceptance rate of 100 aircraft per hour.

All of the airport capacity estimates used in the analysis for the future years are based on airport airfield improvements projected in the Aviation System Capacity Plan and new technologies expected to be implemented by the year 2005. The TAF (FY 95-2012) was used to project traffic growth for the future years. These forecasts depend on many factors that are subject to change, such as economic and technological changes. The annualization method used in the scenarios was an approximation, based on weather observations taken from the year 1990. The model does not include rerouting or other methods used to minimize the impacts of adverse weather.

New technologies likely to be in place by the year 2005 are designed to increase airport capacity without adding or extending new runways. The following is a list of future improvements that were assumed to be in place and their effects modeled.

a. Precision Runway Monitor (PRM):
   This would allow simultaneous parallel IFR arrivals on runways spaced between 3,000 and 4,300 feet ATL, CLT, MSP, RDU, CLE, JFK, and PHL are likely to be equipped with PRM by year 2005. See Appendix A for airport identification.

b. Final Monitor Aid (FMA):
   Improved resolution would allow simultaneous parallel IFR approaches on dual runways spaced between 4,000 and 4,300 feet without full PRM. Those airports that would take advantage of this technology are FLL and DEN.

c. Airport Surface Traffic Automation (ASTA):
   This technology is designed to optimize surface operations through improved sequencing

of departures and more tactical management of aircraft movement. All NASPAC-modeled airports were affected by this improvement.

In addition to improvements in technology, procedural changes for the future systems were also considered, using the NASPAC Evaluation of the Impacts of the Center-TRACON Automation System (CTAS) on Airport Capacity study (Richie & Baart, 1996). The following is a list of the procedural changes designed to increase airport capacity.

a. CTAS:
NAS-wide implementation of CTAS would optimize final approach separations by more efficiently distributing en route delay.

b. DCIA:
The reduction of terminal separation minima may be realized by monitoring aircraft approaching converging runways more accurately. Those airports affected include BOS, CLE, CLT, CVG, MEM, MKE, PHL, SFO, and STL. See Appendix A for airport identification.

c. Reduced Diagonal Separation for Parallel Approaches:
The reduction of diagonal separation from 2 nmi to 1.5 nmi may be realized for parallel runways not eligible for independent parallel approaches and that are 2,500 feet apart. Affected airports include DAL, PHX, PHL, SLC, SJC, SEA, MSP, STL, and DEN.

5. METHODOLOGY

This section describes the procedural details of the study and gives the sources of the capacity and future growth estimates.

5.1 CAPACITY

The STL airport and ZKC sector capacities used in this study were provided by the FAA's Central Region, Airports Division, ACE-611E. These values are based on discussions with STL tower, STL TRACON, ZKC, and other experts in the field who control STL traffic on a daily basis. The 1988 FAA Engineered Performance Standards (EPS) were also used as a reference.

Table 5 shows the capacity values used in the simulations under VMC for STL for all time frames modeled. Table 6 shows the capacity values that were used under IMC . These values represent the maximum, minimum, and 50/50 mix of the hourly departure and arrival rates at these airports. The minimum departure capacity is the hourly departure rate when arrivals are given highest priority (arrival priority). Conversely, minimum arrival capacity exists when departures are given higher priority (departure priority). The minimum service time between successive arrivals and departures are determined from these hourly rates and the subsequent arrival and departure queue lengths. The inverse of these service times are the capacity values that are furnished for each of the 58 modeled airports. As experienced from previous studies, the largest contributor of delay culminates at airports where aircraft compete for runway usage.

TABLE 5. CAPACITY UNDER VISUAL METEOROLOGICAL CONDITIONS (VMC) FOR STL AIRPORT

Time Frame	Maximum Arrival	Minimum Departure	Minimum Arrival	Maximum Departure	50/50 Arrival	50/50 Departure
1995BL	74	30	33	75	50	50
2005BL	74	30	33	75	50	50
2005IM	88	40	40	100	65	65
2010BL	74	30	33	75	50	50
2010IM	88	40	40	100	65	65
2015BL	74	30	33	75	50	50
2015IM	88	40	40	100	65	65

TABLE 6. CAPACITY UNDER INSTRUMENT METEOROLOGICAL CONDITIONS (IMC) FOR STL AIRPORT

Time Frame	Maximum Arrival	Minimum Departure	Minimum Arrival	Maximum Departure	50/50 Arrival	50/50 Departure
1995BL	36	22	24	40	30	30
2005BL	36	22	24	40	30	30
2005IM	54	24	30	76	45	45
2010BL	36	22	24	40	30	30
2010IM	54	24	30	76	45	45
2015BL	36	22	24	40	30	30
2015IM	54	24	30	76	45	45

Note: BL = Baseline IM = Improvements (Master Plan Supplement in place)

5.2 RESTRUCTURING STL AIRSPACE AND TERMINAL AREA

In addition to expanding STL airport capacity, the Master Plan Supplement calls for modifications to the surrounding airspace. More arrival and departure streams will be added and sectors will be restructured. For example, sectors ZKC21, ZKC31, ZKC41 and ZKC97 were added in 1996 to enhance the ZKC sector load, and ZKC63 was removed. New navigational and surveillance aids will be installed as well.

To model the arrival stream changes, an additional pseudo-fix was added at each corner-post, representing the additional parallel stream for satellites. (In the NASPAC model, multiple "fixes" may be located at the same latitude/longitude, but at different altitudes.) The existing main and parallel streams were not separated in the model, because the distance was not significant at the level of details at which NASPAC operates. The additional fix was given the same capacity as the old parallel fix.

Other airspace changes, while operationally significant, were not included in the study. NASPAC, being a system-wide simulation model, does not model terminal airspace explicitly. Therefore, some planned modifications either could not be represented in the NASPAC model or were unlikely to have any effect on the results of the simulations.

5.3 FUTURE DEMAND FORECASTS AND INPUT DATA

The demand used to run the model consists of unscheduled demand from historical data (tower counts at modeled airports) and scheduled demand derived from the Official Airline Guide (OAG). The 1995 demand levels were used as a baseline for predicting the future demand. The projected growth at STL, and the other airports in the NAS, were provided by the FAA's Office of Aviation Policy and Plans (APO) through the TAF (1995-2012). This file consists of air carrier and general aviation (GA) operations.

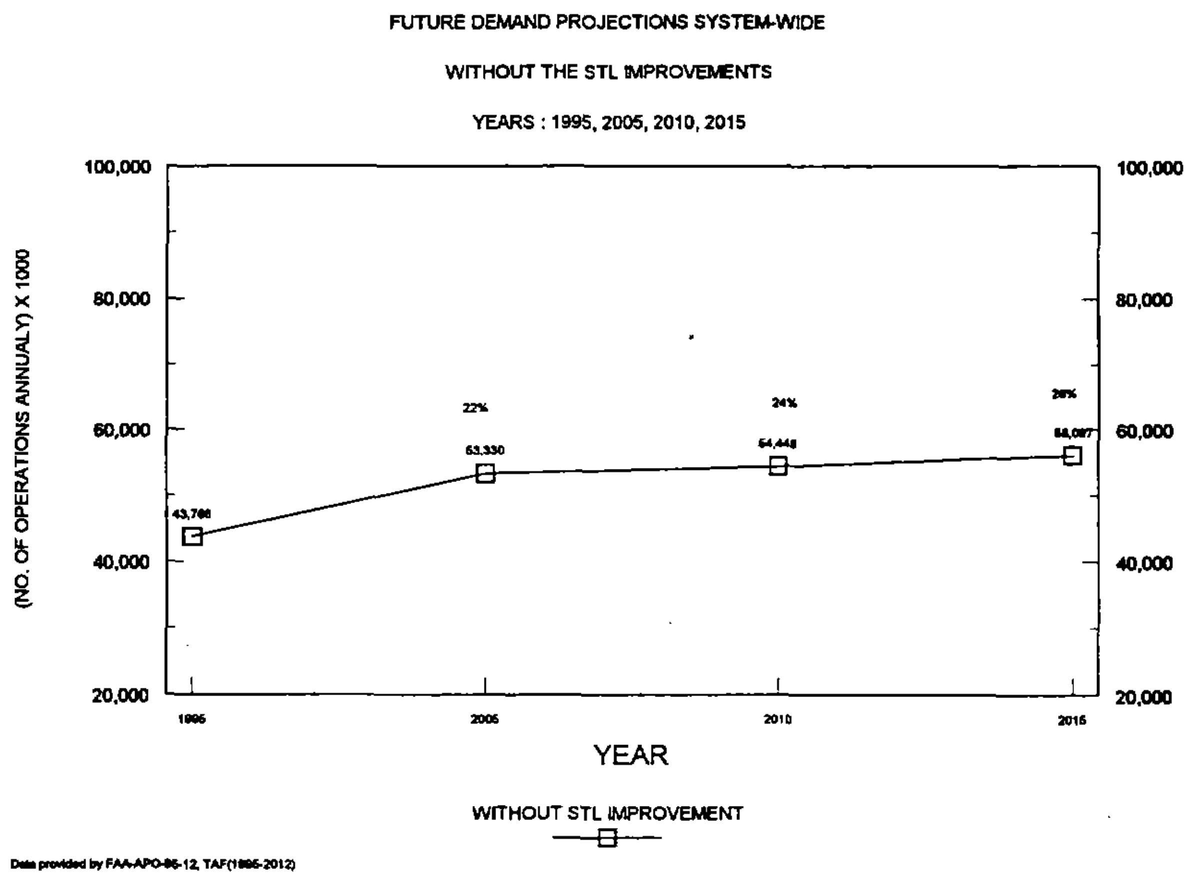
The model also accounts for ground delay issued by the Traffic Management Command Center (TMCC). This type of delay is usually due to adverse weather conditions at the destination airport or any enroute restrictions. The Estimated Departure Clearance Times (EDCT) are computed and appended to the schedule for each affected flight. For example, as aircraft enter the departure queue, they are ordered according to their assigned EDCT, if any. Aircraft with no EDCT or with an expired EDCT will be ahead of any aircraft with an EDCT. Thus if the first aircraft in the queue has an unexpired EDCT, all other aircraft in the queue have the same or a later EDCT. Aircraft with no EDCT or aircraft with the same EDCT are ordered in the queue in first in first out (FIFO) priority.

The unscheduled demand is described by daily and hourly distributions taken from real world data (tower counts). The primary source of the IFR General Aviation (GA) and military flights is the

"Host_Z" data. The data are collected by the ARTCCs and sent to the FAA William J. Hughes Technical Center by satellite for each flight in the system. The data are sent to the Transportation System Center for processing and is then distributed to the TMCC and other users. The weather data used in the model were taken from surface observations at all of the modeled airports.

Figure 2 shows the forecasted number of annual operations system-wide. The growth between 1995 and 2015 with the STL improvement plan is based on the TAF. These values represent an estimated 22 percent growth from 1995 to 2005; 24 percent growth from 1995 to 2010; and 28 percent growth from 1995 to 2015.

FIGURE 2. FORECASTED NUMBER OF ANNUAL OPERATIONS SYSTEM-WIDE

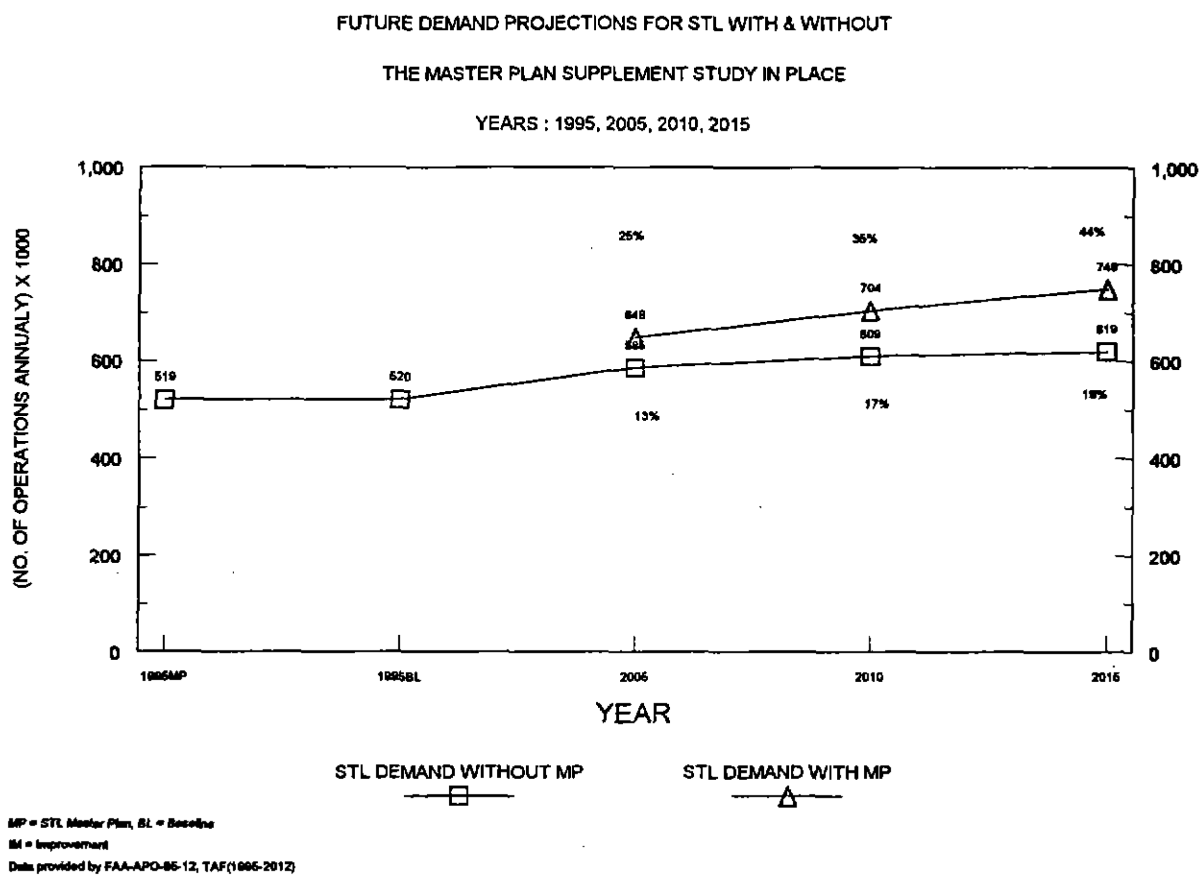


Note: Numbers of operations for the future years are assumed to increase linearly.

The TAF projections for future demand at STL (and other airports) take into account the increase in capacity that accompany airport expansion. For the cases in which the future years were simulated without the STL improvements, the demand was scaled back to compensate for growth attributable to the Master Plan itself. We examined growth projections for other airports in the region with no planned improvements and scaled back STL traffic accordingly. Scaling back the demand yields more realistic estimates of the airport effects. This is a standard practice for NASPAC studies.

Figure 3 shows the forecasted number of annual operations at STL. The growth between 1995 and 2012 with the Master Plan in place was forecasted by the TAF (FY 1995-2012). For the 2015 case, we used interpolation techniques to calculate future growth. These values represent an estimated 13 percent growth from 1995 to 2005; 17 percent growth from 1995 to 2010; and 19 percent growth from 1995 to 2015 for the baseline case (without the master plan). The improvement case (with the master plan) shows a higher demand as expected, with 25 percent growth from 1995 to 2005; 35 percent growth from 1995 to 2010; and 44 percent from growth from 1995 to 2015.

FIGURE 3. OPERATIONS AT STL AIRPORT



Note: Numbers of operations for the future years are assumed to increase linearly.

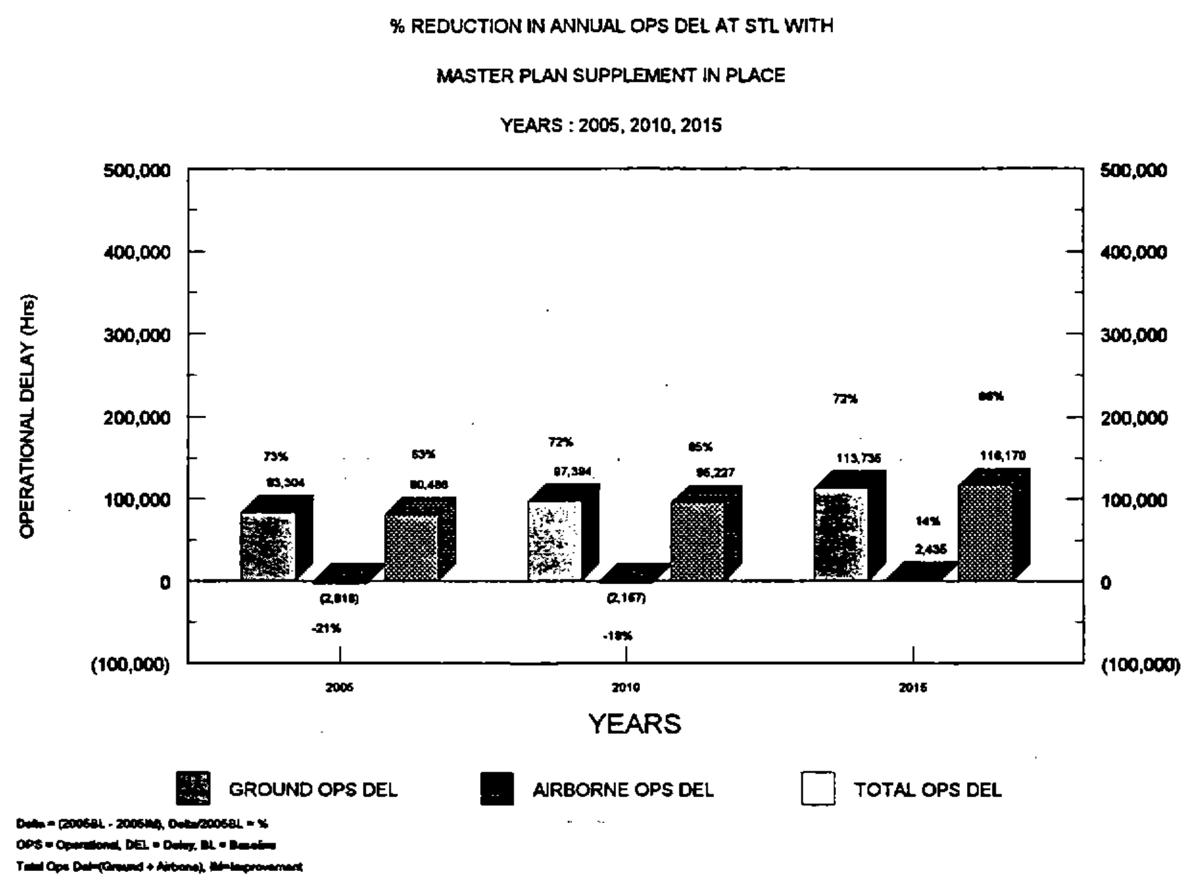
6. RESULTS

6.1 STL OPERATIONAL DELAY AND OPERATIONAL DELAY COST

Operational delay consists of airborne and ground delay. Airborne operational delay is the sum of airport arrival delay, arrival fix delay, departure fix delay, sector delay, and delay resulting from static and dynamic flow control restrictions. Ground operational delay, or airport induced delay accumulates when an aircraft is ready to depart, but has to wait for a runway to taxi-out or take off from, or when airfield capacity limitations prohibit the aircraft from landing

Figure 4 shows the annual savings in operational delay at STL that could be realized with the runway improvements identified in the Master Plan. These results are based on simulations of the NAS with and without the added airport capacity at STL.

FIGURE 4. SAVINGS IN OPERATIONAL DELAY AT STL WITH THE MASTER PLAN IMPROVEMENTS

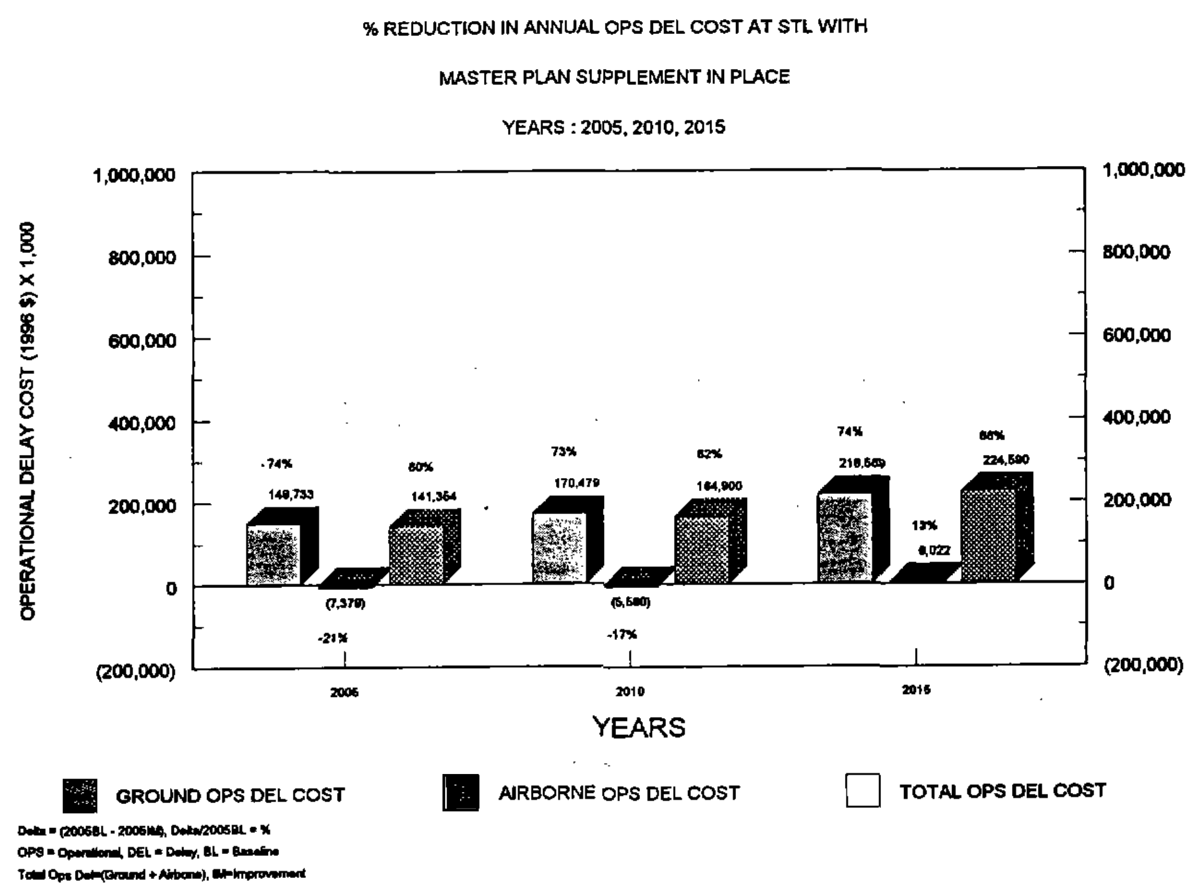


Note: "Ground operational delay" and "Airport induced delay" refer to the same thing.

Figure 5 compares the difference in delay costs for the years 2005, 2010, and 2015 with and without the Master Plan. This shows the monetary equivalent the Master Plan delay savings for each year modeled. The results are broken down by ground delay cost, airborne delay cost, and total operational delay cost. The refinements in the results are designed to allow the decision makers to see where the benefits are occurring.

In 2005 and 2010, the savings in the airborne delay is shown to be negative which indicates an increase in the airborne delay cost with the Master Plan in place. These increases are 21 percent in 2005, and 17 percent in 2010. The increase in cost for these two years are attributed to the changes in arrival and departure times due to airline schedule changes as simulated. On the other hand, the reduction in the ground operational delay, or airport induced delay cost outweighs by far the increase in the airborne delay cost for those two years. The total operational delay savings, which consists of the sum of the ground delay savings and the airborne delay savings, are enormous across the board. In 2005 it shows a total of $141,354,000 in savings or 60 percent; 2010 shows a total of $164,900,000 in savings or 62 percent; and 2015 shows a total of $224,590,000 in savings or 66 percent.

FIGURE 5. SAVINGS IN OPERATIONAL DELAY COST AT STL WITH THE MASTER PLAN IMPROVEMENTS



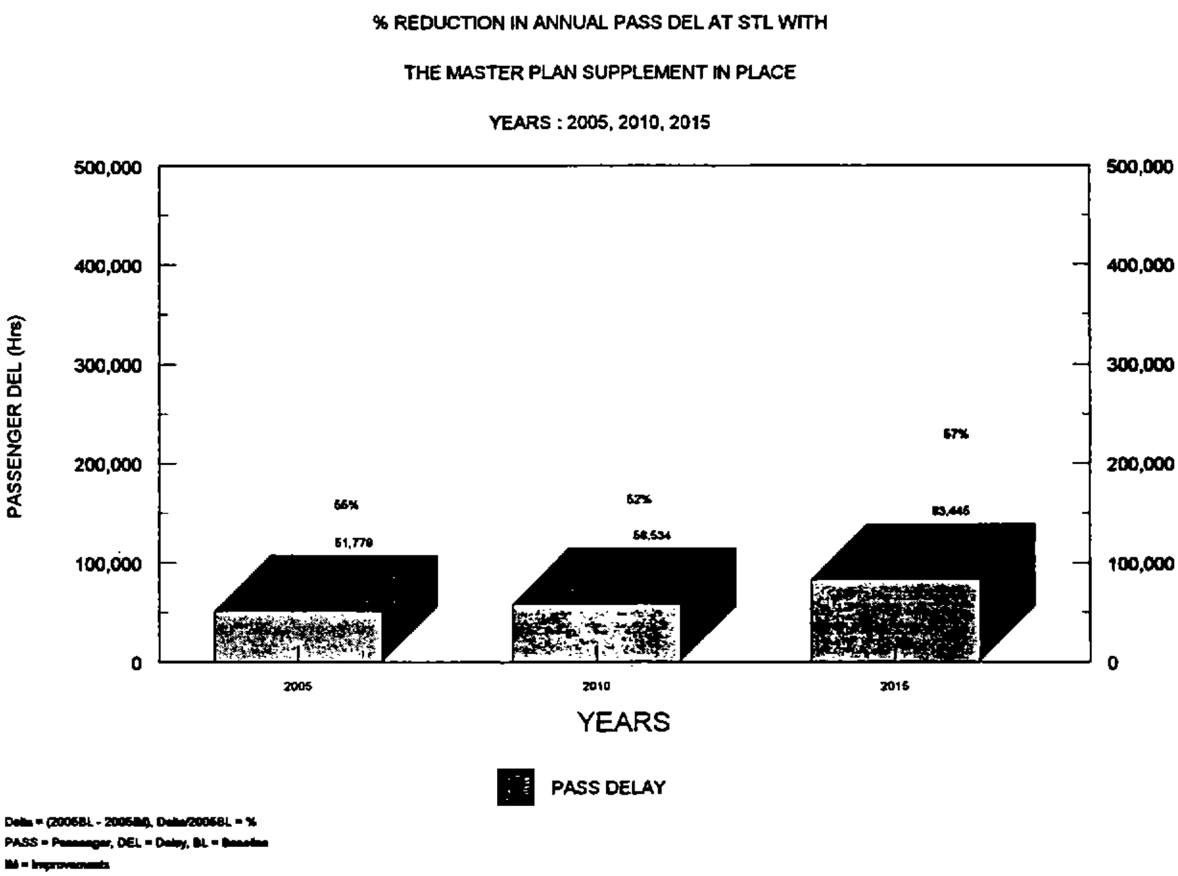
6.2 STL AIRPORT PASSENGER DELAY AND PASSENGER DELAY COST

Passenger delay is the difference between the scheduled and actual arrival times recorded in the simulation, regardless of the cause. An aircraft that arrives on time and accumulates no passenger delay can still accrue operational delay.

The savings in passenger delay resulting from the Master Plan is depicted in figure 6. These savings are shown for the three time frames that were modeled.

The reduction of passenger delay is estimated to be 51,778 hours or 55 percent in 2005; for 2010 it is 58,534 hours or 52 percent; and for 2015 it is 83,445 hours or 57 percent.

FIGURE 6. SAVINGS IN PASSENGER DELAY AT STL WITH THE MASTER PLAN IMPROVEMENTS

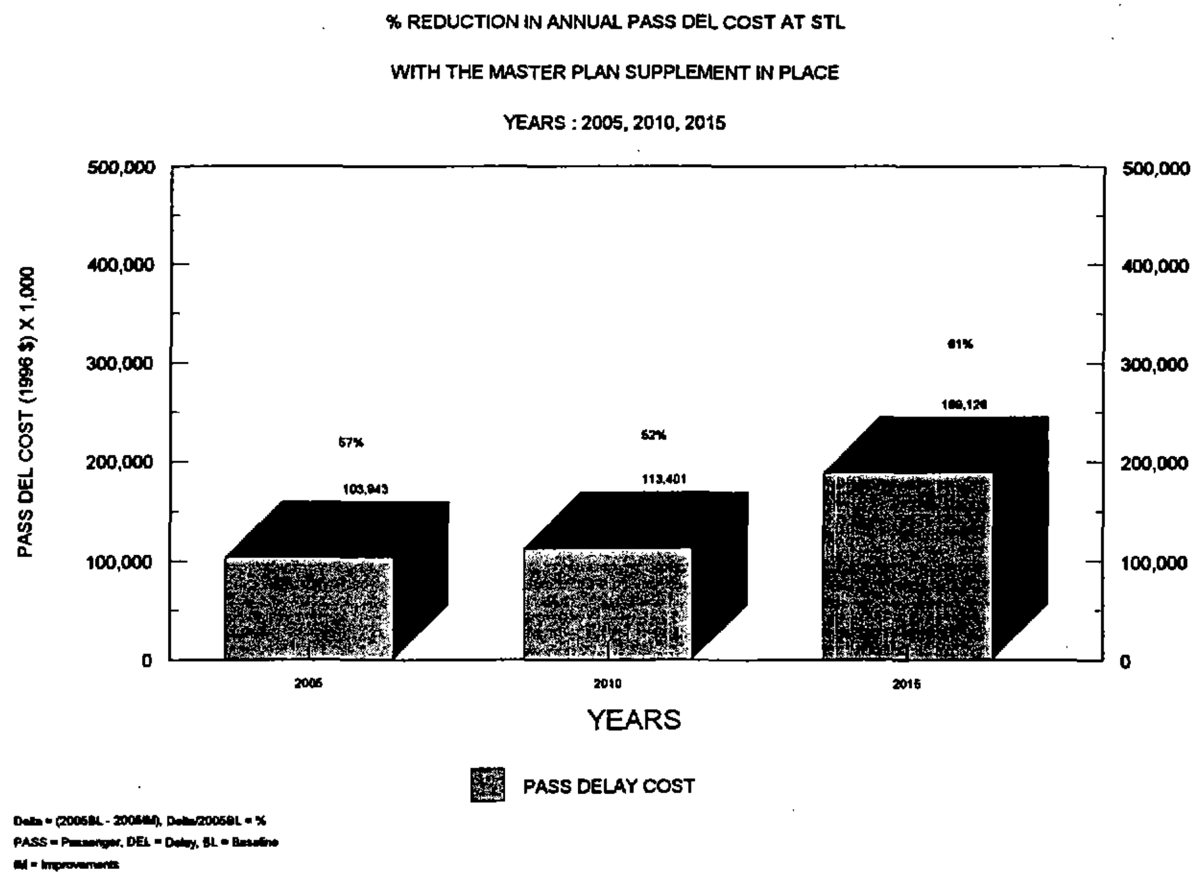


Note : The terms "pass" and "pas" are used interchangeably to describe passenger delay.

The savings in the passenger delay cost due to the implementation of the Master Plan are shown in Figure 7. These savings are significant to the traveling public and are estimated to be

$103,943,000 or 57 percent in 2005; $113,401,000 or 52 percent in 2010; and $189,126,000 or 61 percent. These values are the difference between the future years 2005, 2010, and 2015 with and without the Master Plan.

FIGURE 7. SAVINGS IN PASSENGER DELAY COST AT STL WITH THE MASTER PLAN IMPROVEMENTS



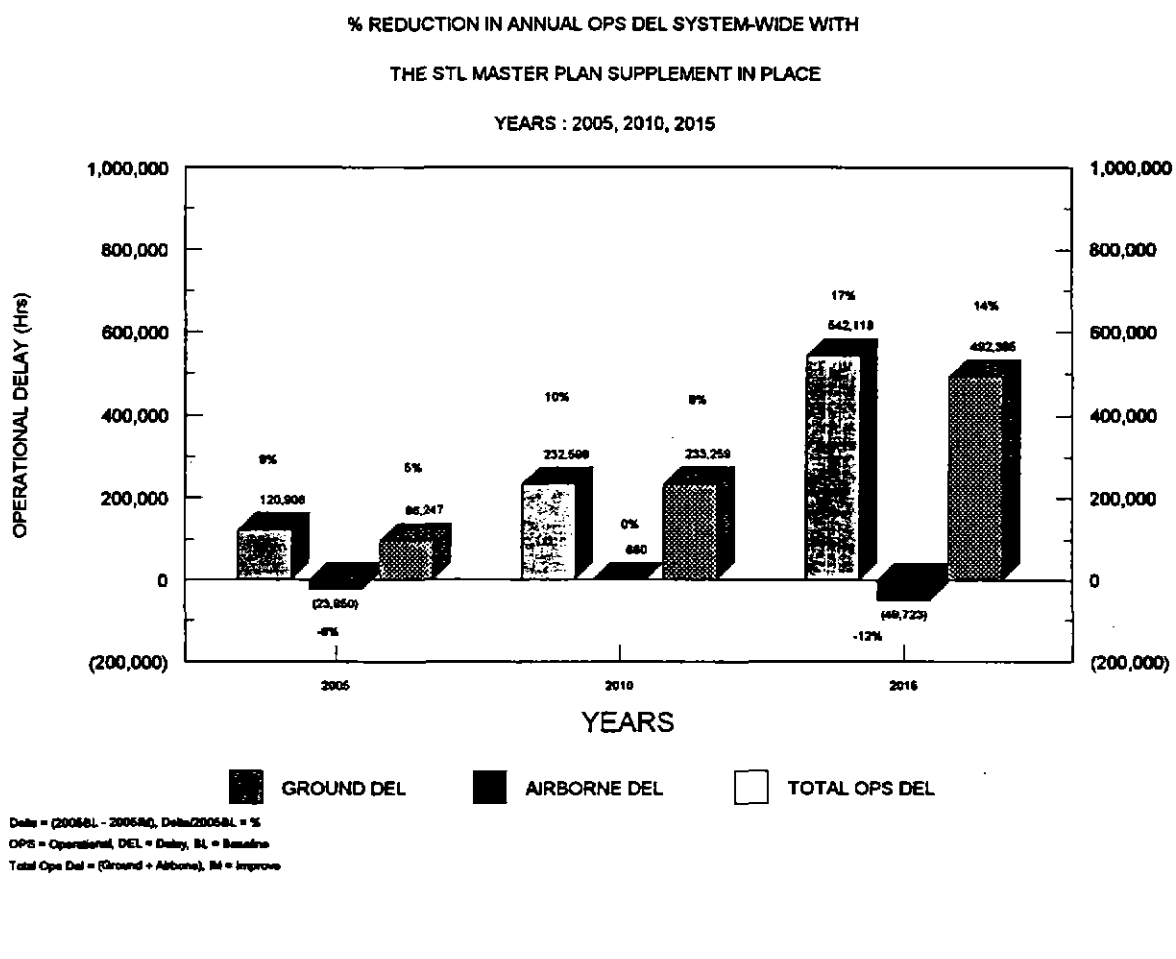
6.3 SYSTEM-WIDE OPERATIONAL DELAY AND COST

This study generated reasonable and conservative estimates of the delay by scaling back the future demand generated by the STL improvements built into the TAF, under a variety of possible conditions applied in the six scenario days to calculate the annual results. For the future years modeled, the demand was scaled back to compensate for the growth attributed to the STL Master Plan itself.

The results are broken down by ground delay or airport induced delay, airborne delay, and total operational delay with the majority of the delay being airport induced. Figure 8 shows the savings in operational delay system-wide. These savings are the total savings from a national point of view that may be realized with the implementation of the Master Plan.

In 2005 and 2015, the airborne delay savings is shown to be negative which indicates that the airborne delay has increased with the Master Plan. These increases are 23,850 hours or 6 percent in 2005; and 49,723 hours or 12 percent in 2015. The increase is attributed to the changes in the arrival times in the simulation. This is due to the increase in the airport capacity at STL, thus, allowing aircraft to arrive at STL at a faster rate. This will enhance operations at airports that share traffic with STL, causing a ripple effects throughout the system. On the other hand, the ground delay or airport induced delay shows a huge reduction for all the time frames modeled which outweighs the increase in the airborne delay. The year 2005 shows a total reduction of 96,247 hours or 5 percent; 2010 shows a total of 233,259 hours or 8 percent; and 2015 shows a total of 492,395 hours or 14 percent.

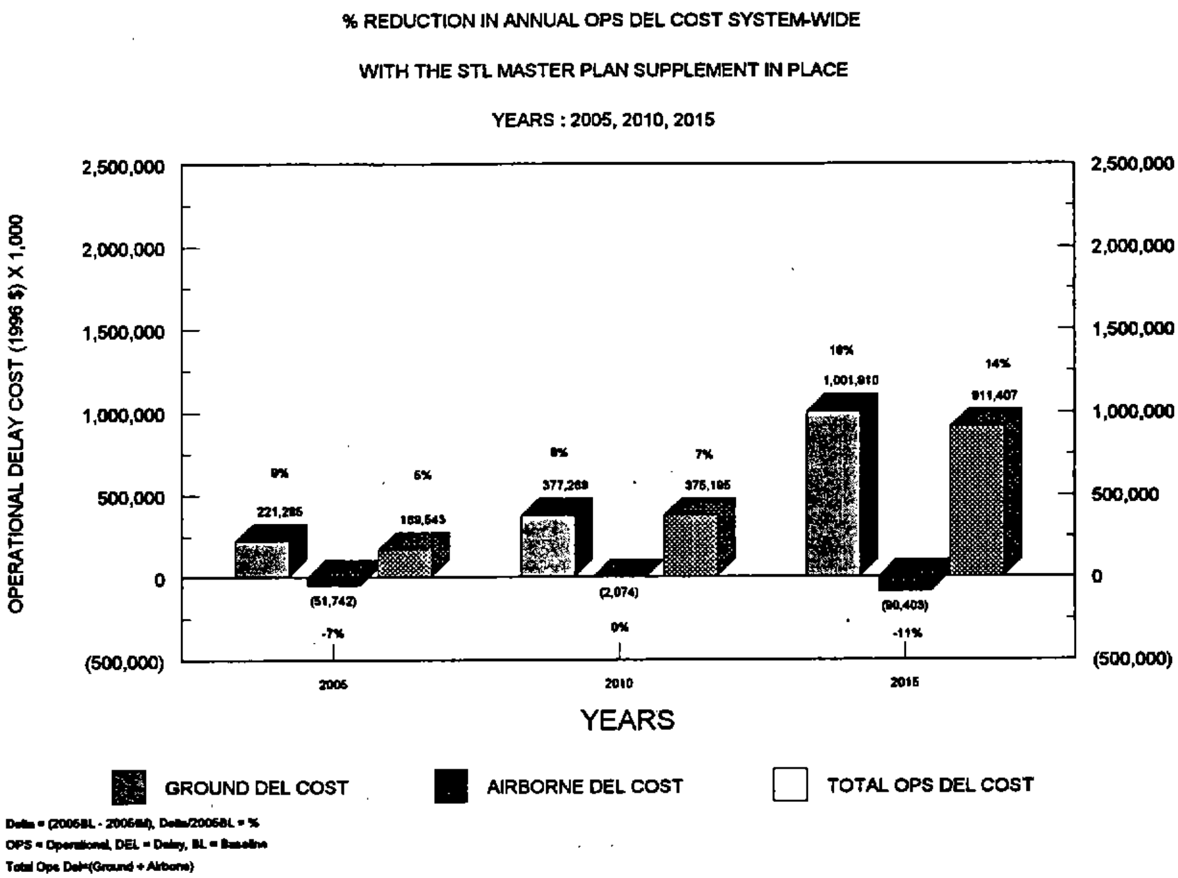
FIGURE 8. SAVINGS IN OPERATIONAL DELAY SYSTEM-WIDE WITH THE MASTER PLAN IMPROVEMENTS



The Master Plan at STL also indicates monetary benefits system-wide. The gain is approximately equivalent to the benefit realized at STL for one year because the improvements are taking place at STL. Figure 9 shows this gain broken down by ground, airborne, and total cost. In all of the future years modeled (2005, 2010, and 2015), the airborne delay savings cost is shown to be negative, this indicates that the airborne delay cost has increased with the Master Plan. These increases are $51,742,000 or 7 percent in 2005; $2,074,000 or less than 1 percent in 2010; $90,403,000 or 11 percent in 2015. These increases are attributed to an improvements in arrival time as shown in the simulation.

On the other hand, the ground delay cost shows large savings for all time frames modeled which outweighs the increase in the airborne cost. The total savings are projected to be $96,247,000 or 5 percent in 2005; $223,259,000 or 8 percent in 2010; and $492,395,000 or 14 percent in 2015.

FIGURE 9. SAVINGS IN OPERATIONAL DELAY COST SYSTEM-WIDE WITH THE MASTER PLAN IMPROVEMENTS

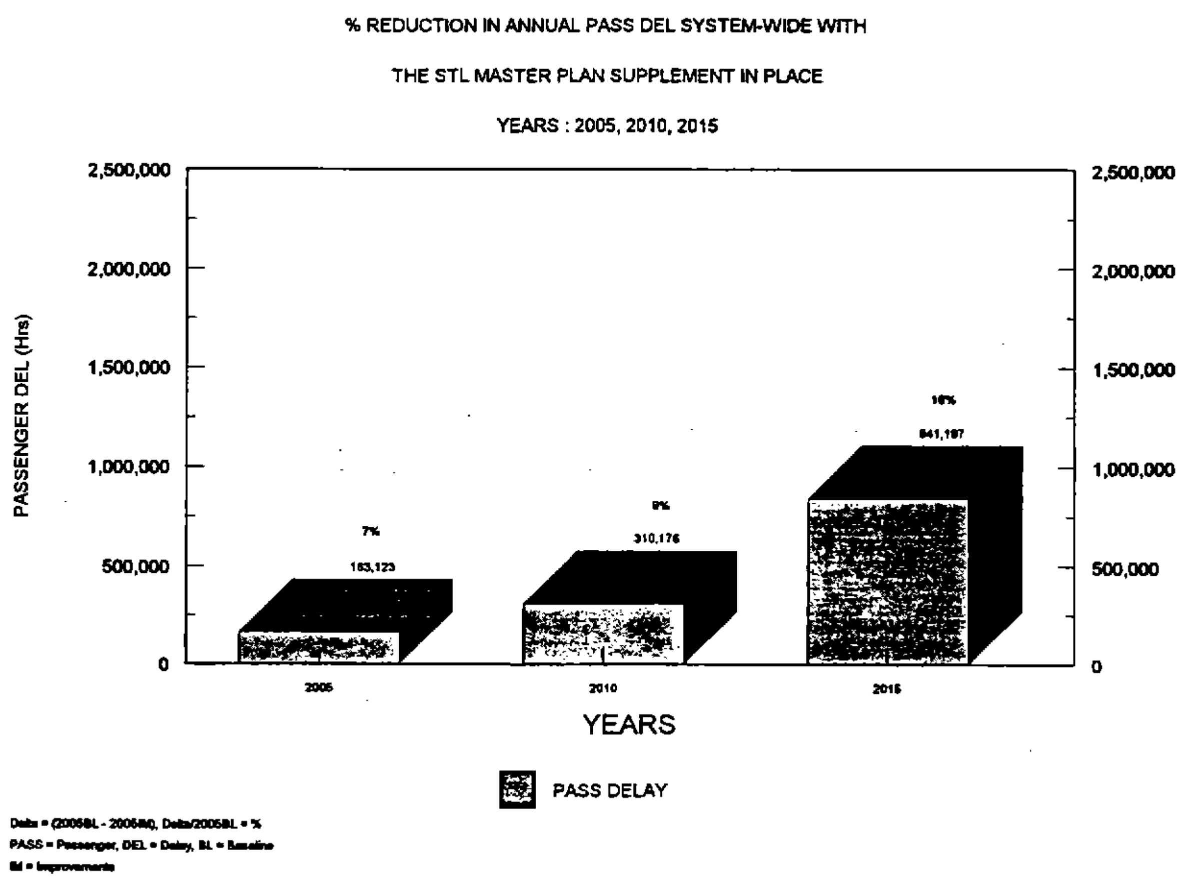


6.4 SYSTEM-WIDE PASSENGER DELAY AND COST

In contrast to system-wide operational delay, the reductions in passenger delay system-wide were greater than the reduction in passenger delay at STL. Passenger delay reflects the ripple-effects of delay at a given airport. Since STL may be one leg of an aircraft's itinerary, the on-time performance of flights passing through STL would result in improved on-time performance of airports which serve STL. The increased capacity at STL would, thus, improve the on-time performance of successive legs of a flight's itinerary which pass through STL.

Figure 10 shows savings in passenger delay through out the NAS. These values represent the differences between the future years modeled with and without the Master Plan. The reductions are projected to be 163,123 hours or 7 percent in 2005; 310,176 hours or 9 percent in 2010; and 841,197 hours or 18 percent in 2015.

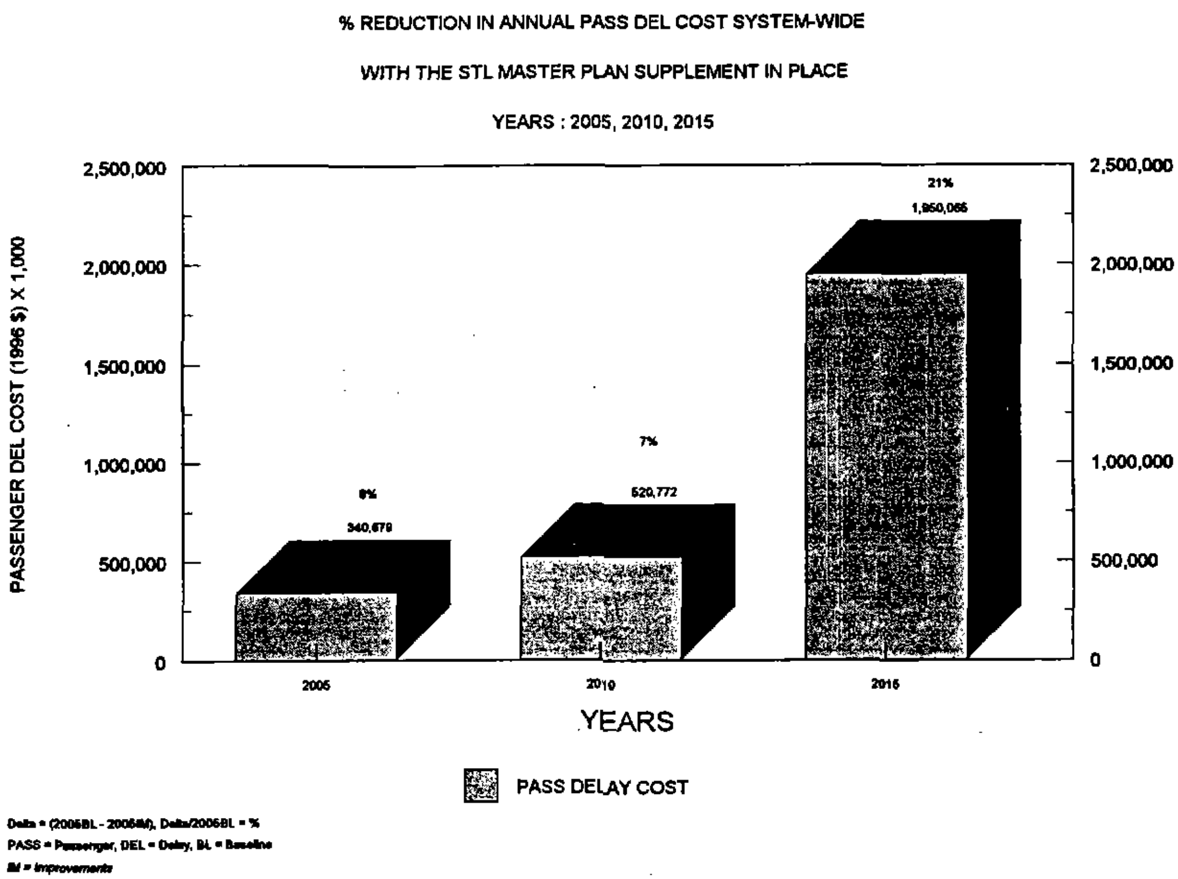
FIGURE 10. SAVINGS IN PASSENGER DELAY SYSTEM-WIDE WITH THE MASTER PLAN IMPROVEMENTS



The analysis has shown that airports with the most STL traffic will have greater benefits than the rest of the NAS. However, some airports have shown increase in delays with the Master Plan. A reasonable explanation might suggest that the additional traffic that STL accommodates would result in more departures. This would place a greater demand on arrivals for those airports that are served by STL. This increase coupled with no capacity enhancements would yield greater delays. The results for individual airports should be interpreted cautiously, in-as-much as they only pertain to the specific simulation scenarios. Moreover, in the real world, traffic flow management would probably mitigate these effects using methods not captured by the simulation.

The Master Plan also indicates monetary benefits system-wide to the passengers. The savings estimates and percentages are provided in Figure 11 which shows the monetary equivalent in 1996 dollars based of reduction in passenger delay system-wide. These values represent the differences between the future years delay performance modeled with and without the Master Plan improvements. The passenger savings are projected to be $340,697,000 or 8 percent in 2005; $520,772,000 or 7 percent in 2010; and $1,950,095,000 or 21 percent in 2015.

FIGURE 11. SAVINGS IN ANNUAL PASSENGER DELAY COST SYSTEM-WIDE WITH THE MASTER PLAN IMPROVEMENTS



It is important to understand the monetary savings indicated in this report do not represent cash to be made available on hand, but an estimate of what could be saved by the airline and the passengers with the Master Plan improvements. The benefits to the airlines are based on their direct cost as reported to the Department of Transportation. The passenger cost are assumed to be $45.50 per passenger hour, if they were to be reimbursed for lost time caused by the system.

7. CONCLUSIONS

The study results indicate that the increase in airport capacity provided by the STL Master Plan will result in significant reduction in delay at STL and NAS-wide. A comparison of the reduction in the operational and passenger delay are provided in Table 6. The terms NAS-wide and system-wide are used interchangeably.

TABLE 7. PERCENT REDUCTION IN OPERATIONAL AND PASSENGER DELAY AT STL AND NAS WIDE WITH THE MASTER PLAN IMPROVEMENTS

	2005		2010		2015	
Delays	STL	NAS	STL	NAS	STL	NAS
Operational	63%	5%	65%	8%	66%	14%
Passenger	55%	7%	52%	9%	57%	18%

The STL Master Plan indicate monetary equivalent based on the reduction in operational and passenger delay shown above. Table 7 shows the estimated savings that could be realized by adopting the Master Plan.

TABLE 8. CUMULATIVE SAVINGS WITH THE MASTER PLAN FOR 11-YEAR PERIOD 2005-2015 (Savings in 1996 Dollars)

Location	Operational Delay Savings	Passenger Delay Savings
STL Airport	$1.9 billion	$1.4 billion
NAS-wide	$5.1 billion	$9.5 billion

8. REFERENCES

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APPENDIX A

AIRPORTS MODELED BY NATIONAL AIRSPACE SYSTEM PERFORMANCE ANALYSIS CAPABILITY

Airport Identifier	Airport	Airport Identifier	Airport
ABQ	Albuquerque International	MCI	Kansas City International
ATL	Atlanta International	MCO	Orlando International
BDL	Bradley International	MDW	Chicago Midway
BNA	Nashville International	MEM	Memphis International
BOS	Logan International (Boston)	MIA	Miami International
BUR	Burbank-Glendale-Pasadena	MKE	Milwaukee International
BWI	Baltimore/Washington	MSP	Minneapolis St. Paul International
CLE	Clevland-Hopkins International	MSY	New Orleans Moisant Field
CLT	Charlotte/Douglas International	OAK	Metropolitan Oakland
CVG	Cincinnati/Northern Kentucky	ONT	Ontario International
DAL	Dallas Love Field	ORD	Chicago O'Hare International
DAY	Dayton International	PBI	Palm Beach International
DCA	Washington National	PDX	Portland International
DEN	Denver International	PHL	Philadelphia International
DFW	Dallas/Fort Worth International	PHX	Phoenix Sky Harbor
DTW	Detroit Metropolitan	PIT	Pittsburgh International
EWR	Newark International	RDU	Raleigh Durham International
FLL	Fort Lauderdale/Hollywood	SAN	San Diego Lindbergh Field

HOU	Houston Airport	SAT	San Antonio International
HPN	White Plains Airport	SDF	Louisville Standiford Field
IAD	Washington Dulles International	SEA	Seattle-Tacoma International
IAH	Houston Intercontinental	SFO	San Francisco International
IND	Indianapolis International	SJC	San Jose International
ISP	Islip (Long Island MacArthur)	SLC	Salt Lake City International
JFK	New York (John F. Kennedy)	SNA	Santa Anna (John Wayne)
LAS	Las Vegas International	STL	Lambert St. Louis
LAX	Los Angeles International	SYR	Syracuse Hancock
LGA	New York (La Guardia)	TEB	Teterboro
LGB	Long Beach/Dougherty Field	TPA	Tampa